DOCUMENT RESUME

ED 241 342 SE 044 154

AUTHOR	Weaver, Elbert C.
TITLE	What Is a Gas? A Find-Out Book: Demonstrations, Experiments, Ideas.
INSTITUTION	American Gas Association, Arlington, VA. Educational Services.
PUB DATE	72
NOTE	46p.
AVAILABLE FROM	American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209 (one per teacher).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Class Activities; Elementary Education; *Elementary School Science; Science Activities; *Science Experiments
IDENTIFIERS	*Air; *Gases; PF Project

ABSTRACT

Twelve desk-top experiments and demonstrations which illustrate properties of and facts about gas are presented. Each experiment includes: purpose, materials needed, instructions, and a list of facts and properties that have been observed. Several of the activities also include questions for students and items for discussion. The topics of the activities, which use materials commonly found in the home, are: (1) gases can push; (2) additional examples that gases can push; (3) air pushes upward; (4) compressed air changes temperature when it goes through a small opening into a place of lower pressure; (5) making of a mixture of solids; (6) making of a mixture of liquids; (7) fire needs air to burn; (8) candle wax vaporizes before it burns; (9) determination of the rate at which a candle burns; (10) a cooled flame causes incomplete burning; (11) relationship of carbon dioxide to burning; and (12) observation of carbon dioxide in exhaled air. Also included are a conclusion and summary of the experiments, and lists of facts about gases, materials needed for each experiment, and three other instructional resources available from the American Gas Association. (DC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED241342

WHAT IS A GAS?

- A *Find-Out* Book

Demonstrations, Experiments, Ideas

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Carol A. Smocts

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

prepared by

Elbert C. Weaver
Educational Advisor

produced by

Educational Services
American Gas Association
1515 Wilson Blvd.
Arlington, VA 22209

AGA American Gas Association

SE044154

WHAT IS A GAS?

Contents

Preface

Introduction

Experiment No. 1 What Is a Gas Like?

Experiment No. 2 More about a Gas

Experiment No. 3 Does Air Really Push Upward?

Experiment No. 4 Hot and Cold Air

Experiment No. 5 Making a Mixture of Solids

Experiment No. 6 Making a Mixture of Liquids

Experiment No. 7 Burning in Air

Experiment No. 8 Candle Wax Vaporizes Before It Burns

Experiment No. 9 How Fast Does a Candle Burn?

Experiment No. 10 Incomplete Burning

Experiment No. 11 Making Carbon Dioxide Gas

Experiment No. 12 Carbon Dioxide in Exhaled Air

Conclusion

Summary

Facts about Gases

Supplies

American Gas Association, 1972 Catalog No. N00550

PREFACE

The Educational Services Department of the American Gas Association has prepared these desk-top experiments and demonstrations as a way of encouraging the spirit of inquiry among your students. The guide provides you with a flexible teaching tool—one that not only can help your students become more familiar with the fundamental concepts underlying the idea of a *gas* but also help you prepare demonstrations to enable your students to develop a better understanding of the world in which they live.

It is our hope that you use *What Is A Gas?* to present a series of laboratory-type activities for your students—activities that will make them more observant and curious about their environment.

All of the materials needed can be commonly found in the home. You will find, when you ask the children to bring their own materials from home, that most children want to be helpful and to learn more about familiar things.

Children enjoy and profit immensely from first-hand experiences if they are asked to observe their world closely, to analyze what is happening, and to form possible explanations for the events in that everyday world.

An important part of education is the development of an attitude and an approach toward recognizing and solving problems. The more capable the decision-makers of tomorrow become in observing, understanding, and interpreting experience, the more intelligent should be their future choices and decisions.

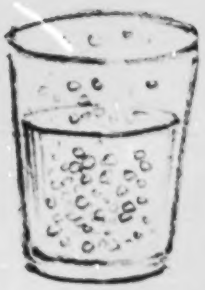
INTRODUCTION

Did you know that your life depends on something you never see, taste, touch, hear, or smell? It is all around you all of the time, and you could not live for more than a few minutes without it. Do you know what this something is? It is air which we shall learn is a mixture of gases.

AIR

Without air you would soon die. Fires could not burn without air. Without air you would have no wind and also a very different sort of weather. Without air, all of the animals and plants that you see would die. Most forms of life would be impossible without air. When the astronauts visited the moon, which has no air, we observed how they had to be provided with life-supporting equipment.

GASES



Air is one example of gaseous material made up of several other gases mixed together. Air is not the only gaseous material that people know about. Many other gases are known. Although other gases are colorless like air, a few of them are colored. Some gases burn. Others put out fires. Some gases are harmless to breathe; some are harmful to breathe. Some of them are very useful. One useful gas called carbon dioxide causes the holes in bread dough and the bubbles in soda water. Still another gas, called chlorine, is put into water to kill germs and to make the water safe to drink. Gases can be useful in many other ways.

To the Teacher

In the first four demonstrations and/or experiments, the children may well note that their five senses enable them to obtain much information about the world in which they live. When it comes to learning something about a gaseous material which may be odorless, colorless, tasteless, weigh very little, and move noiselessly, they are faced with a new experience. In demonstrations #1, #2, and #3 they may guess (surmise, infer, conclude) something about a gas from **seeing** how other objects behave. In demonstration/experiment #4 they again guess (surmise, infer, conclude) something about a gas by **feeling** the temperature of the air.

Throughout the remainder of the demonstrations/experiments, they should note how often knowledge about the world in which they live comes through other than "first-hand" sensory experience. Other knowledge is arrived at by inference; the act of passing from one proposition, statement, or judgment considered as true to another whose truth is believed to follow from that of the former.

EXPERIMENT NO. 1

What Is a Gas Like?
(An experiment for all students)

Purpose: To learn that gases can push, using air to push.

Materials Needed: Strip of paper. Pencil.

What to Do:

1. Each student is given a little strip of paper about one inch wide and three or four inches long.

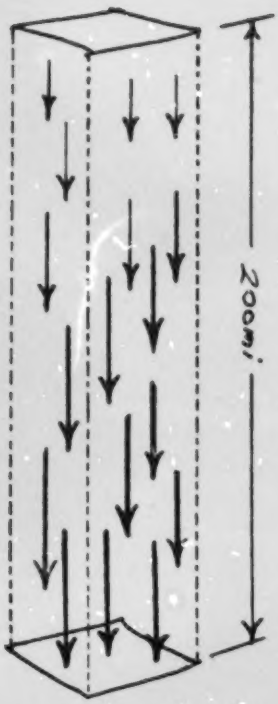
Hold the strip of paper by one end in one hand so that it hangs in front of you. Push it to one side with your other hand so that the paper bends. Take your pushing hand away. The paper comes back to the way it was hanging at first or very close to it.

2. In part 1 the push on the paper was made by your hand or finger. This time the push will be made by a pencil which you hold in your hand.

Hold the strip of paper in one hand as before so that the strip hangs in front of you. Hold a pencil in the other hand. Push the paper to one side with the pencil. Then let the paper come back to the way it was at first. Do this many times. Each time you push, the paper moves. When the push is taken away, the paper comes back to the way it was at first.

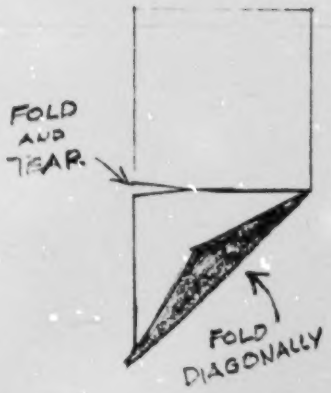
3. This time the push will be made by a gaseous material that you cannot see, the air. A real push is made, however. Hold the paper in front of you as before. Blow your breath gently on the paper. Is the paper pushed away? (Yes, if the aim is good enough.) Does the paper return when you stop blowing? (Yes.) Can your breath make a push? (Yes.) Other gases also can make a push, although we cannot see many of them. We do not see gases push, but we say they push because we do see things being moved just as the paper was moved.

In nature outdoors the air pushes on trees, signs, and buildings. What is this moving air that pushes called? (Wind, breeze.)

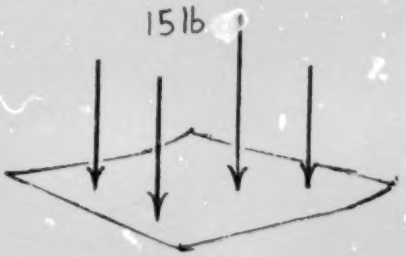


4. Now fold the end of the strip of paper diagonally and then across it as shown in the sketch. Then fold the paper so as to make a crease across it. Make the crease at the fold sharp by rubbing your fingernail across it several times. Now tear the paper at the crease. Use the other end of the paper and try again if a straight tear was not made.

The piece torn off is about one inch long and one inch wide. What is this surface called? (It is a square, one inch long on each of the four sides, and its surface is called a square inch of area, or of surface.)



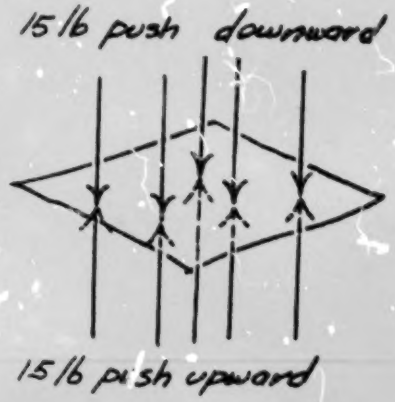
5. The force or push of gases is measured on a surface. The force or push right now of the air above it on the surface of the one-square-inch piece of paper is about 15lb (actually 14.7 lb at sea level).



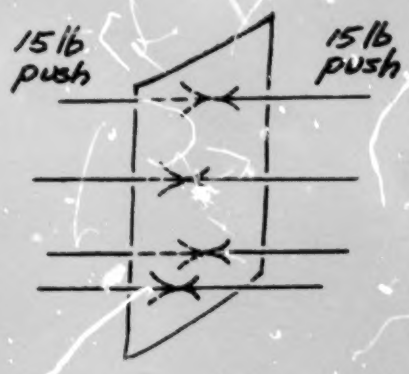
6. Place the square of paper on your desk top. The air above it, as high as the air goes (about 200 miles), pushes down on the square inch with a push of about 15 lb. Now lift the paper. Did it seem to weigh 15 lb? (No.) Note: Your shoes may weigh about one-half pound, and a large school textbook weighs one lb or more.

Pick up the square of paper. It comes up easily, not as if it had a heavy weight of 15 lb on it. Is it right that the air pushes against the square with a push of 15 lb on the square inch? (Yes.)

Ask the students to place the palms of their hands together and to push one against the other, but to push equally with both hands so the hands do not move. This illustrates an equal push in opposite directions. Does this give you a possible explanation for the light weight of the paper?



7. Now compare the pushes on the hands with the pushes on the paper. As you hold the square of paper flat in front of you, how much push is downward on the top side? (15 lb) How much push is upward on the under side? (15 lb) Turn the paper square and hold it up and down vertically with an edge toward you. How much push is on the left side? (15 lb) How much push is on the right side? (15 lb)



Air differs from your hand or from the pencil in its way of pushing. Your hand pushed the paper in one direction. The pencil pushed the paper in one direction. The directed puff of breath from your mouth pushed the paper in one direction. A gas pushes equally to the same extent in all directions all at once, **if the gas is still.** If this is true, where can the valve on a bicycle tire be placed? (Anywhere that is convenient.) A blown-up rubber toy used by children in bathing becomes broken. Does it make any difference where the hole is, or do the gases within the toy rush out of a hole at any place in the rubber? (At any place.)

8. **Moving** air shows an extra push in the direction it is moving. Hold the square of paper by its edge and flat in front of your face. Blow gently against the square. Which way does the square move? (Away from the blower.) What happens when you stop blowing? (Paper comes back to first position.) If you blow with a push of one lb, how much push was on the square? (One lb in that direction.) Note: Since the push of the air is the same on both sides of the paper square, the push of the still air itself can be left out for this question. The push or force on the one square inch of surface is one lb in the direction you are blowing. One lb of push on one square inch of surface is called the **pressure** on that surface. All gases act the way air does. They make a push on a surface, and the push is measured as a pressure. What is pressure? (Push.) How is it measured? (Push on a square surface; force per unit of area; push measured in terms of unit areas.)

9. In part **5** it was stated that in still air the push of air is about 15 lb on a square inch of surface. This push is on both the front and the back surface of the paper. By blowing, a push of one lb was added to the near side. The total push on the near side was then how much? (16 lb) How great a push does the air make on the far side? (15 lb) If the paper is then held in front of you and you blow steadily and drop the paper while you blow, which way does the paper move? (Away from you and downward.) How much push or force

PRESSURE:
1 lb PER SQUARE
INCH, ADDED

is making the paper move? (The force of the breath blown against it. In this case, one lb on a square inch, or a pressure of one lb for each square inch.) Try it. Now pick up all the papers and put them in the classroom waste-basket.

What have you observed about the mixture of gases called air? The same observations are true about gases.

1. A gas can push on a surface.

2. The push is measured in terms of units of square surface (square inch, square foot, square centimeter, etc.).

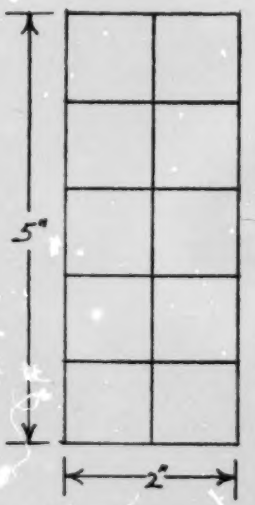
3. In measuring push or pressure, the pressure of still air (14.7 lb per square inch at sea level) may be left out.

Questions for the Class:

a. John blows against one side of sheet of paper with a push of five pounds. Mary blows against the other side of the same paper with a push of four pounds. Which way does the paper move? (Towards Mary.) With how much push? (5 lb - 4 lb = 1 lb.)

b. If a paper measures 5 in. long and 2 in. wide, how much surface does it have in sq in? (5 in x 2 in = 10 sq in.)

c. A push of 20 lb against one side of the paper described in question 2 makes how great a pressure? (Force (20 lb) on area (10 sq in) makes 20 lb per 10 sq in—or 2 lb on each sq in.)



EXPERIMENT NO. 2

More about a Gas

Teacher Demonstration

Purposes: To show that gases can push, using other examples.

Materials Needed: Rubber toy balloon.

What to Do:

Inflate the balloon. (Note: A toy balloon inflates easier if it is first stretched and then inflated in advance of the class.)

Pinch the neck of the inflated balloon and hold the rubber folded over on itself with your fingers while you ask the class such questions as:

"What is in the balloon now?" (Air, your breath, etc.)

"How did I get my breath into the balloon?" (You blew it in or pushed it in.)

"What will happen if I take my fingers off the neck of the balloon?" (Air will go out.) Hold the balloon while you release the neck and let the air out slowly.

"What made the air go out of the balloon?" (Air within the balloon had greater push (or force, or pressure) than the air in the room.)

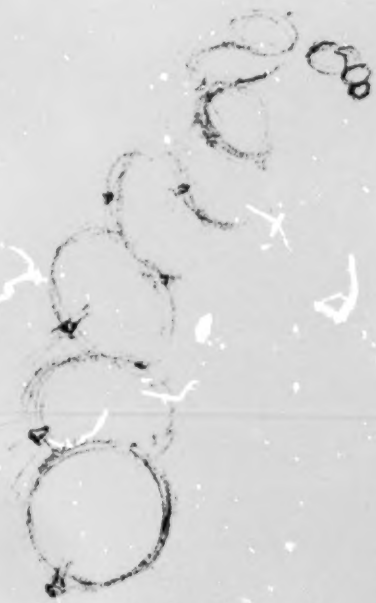
"What gave the air within the balloon the push needed to get it out?" (The force or pressure of the air in the balloon was greater than the pressure of the air outside.) Inflate the balloon once more and, holding it cradled in the hand, let the air escape.

"Did the balloon press against my hand as the air left the balloon?" (Yes.)

"What will happen if I simply let go of the balloon?" (It will move.)

"In which direction will it move?" (Away from the opening.) Hold the air-filled balloon high where all can see it and let go quickly. The balloon moves rapidly and often irregularly around the room.

"What made the balloon move?" (Pushes always come in pairs. When you walk, your foot pushes against the floor, and the floor pushes back against your foot. When you throw a ball against a wall, the wall pushes against the ball and the ball bounces back.

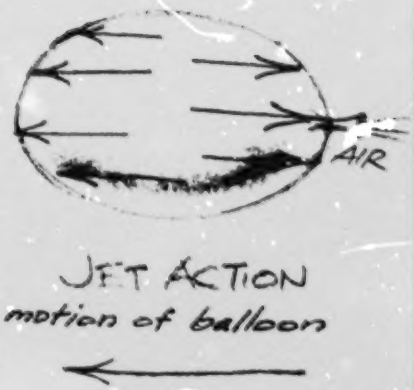


When the air rushes from the neck of the balloon, it pushes back against the walls of the balloon. As the air rushes out, the balloon moves in the opposite direction. The balloon moves in the direction away from the opening. The motion is called jet action.)

"How long does this jet-action flight of the balloon last?" (Until the pressure or force against the inside wall of the balloon becomes equal to the pressure or force at the opening of the balloon.)

"How could a longer jet flight be made?" (Put more air into the balloon, which is another way of saying increase the pressure or push of the air in the balloon.)

Have fun. The class will enjoy whatever happens.



What have you observed?

1. A gas can be held within a container.

2. To put more gas into a balloon or a container, push it in.

3. If the walls of the container stretch as does the rubber of the balloon, the walls stretch more when more push (force) is given to the gas.

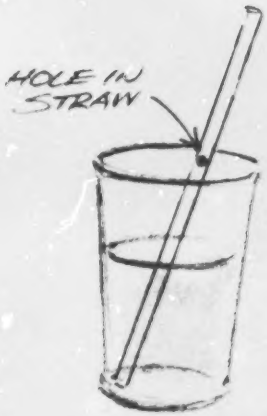
Additional Ideas That May Be Demonstrated or Discussed

1. If the walls of the container are strong steel, the walls stretch much less (invisible to the unaided eye); the walls push back with the same push that the gas has.

2. If a hole is made in a container of a gas, the gas escapes until it has no more push to make it come out. When does it stop coming out? (Push inside equals push outside; better: pressure inside equals the pressure outside the container.)

3. If the gas leaks out of a container of gas until the container is "empty," does all the gas come out? (Not all comes out at first. The gas comes out rapidly until the push to get out becomes equal to the push of the air to get in.)

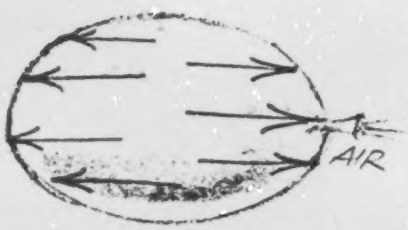
4. Call attention to another way that a gas can be made to go into a container. (The pressure within the container is made less than the pressure of the supply of gas outside the container. Use a paper bag, shirred up at the top. Suck air from it and it collapses. Put a hole in the bag and see what happens when you try to draw the air out. Draw water from a glass through a straw. What do you observe happening when the pressure of the air is reduced above the water in the straw? Place a pin hole in the straw between the surface of the water and the lips. What happens now when you try to draw water up into the straw?)



5. If you throw a ball against a sturdy wall, it bounces back. When a ball is thrown against a window, it doesn't always bounce back. Explain. (The window doesn't push back with a force equal to that of the ball.)

What have you observed?

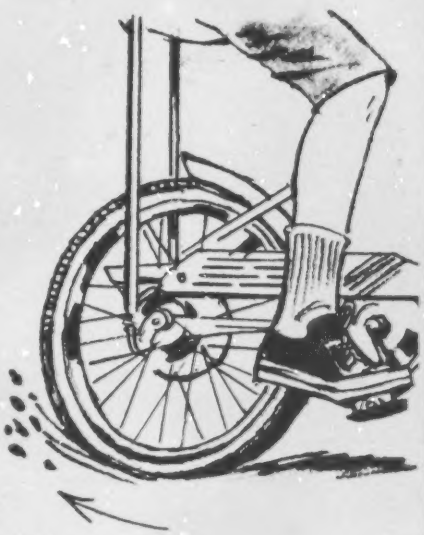
When a gas leaves a still container through an opening, the push in the direction of the opening is the same as the push against the walls of the container opposite the opening. The gas continues to leave a still container as long as the push (pressure) inside the container is greater than the push (pressure) outside the container.

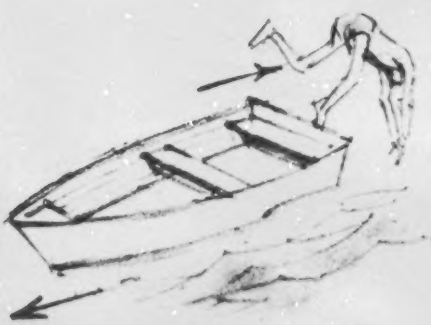


JET ACTION

Further Discussion

If the container is free to move and the force of the escaping gas is great enough to overcome resistance, the container moves in the direction opposite the direction of the escaping gas. A push forward balanced by an opposite push may be seen when the wheels of a car or bicycle push against the road and the road pushes back against the wheels. What happens if the road isn't strong enough to push back enough? (Dirt, stones, etc. fly from the surface of the road.) In which direction does the outlet of a jet plane engine point? (Away from the direction in which the plane moves.) A boat is floating free in the water. You dive off the stern. What happens to the boat? (The boat moves in the direction of the bow.)





EXPERIMENT NO. 3

Does Air Really Push Upward?

Teacher Demonstration

Purpose: To show that air pushes upward.
Materials Needed: Paper drinking cup (small size). Cardboard square that covers the opening of the cup. Water. Pan (in case the water spills).

What to Do:

1. Put the drinking cup on a level surface.

2. Fill the drinking cup completely with water, enough so that the water "crowns" a little over the edge of the cup.

3. Place the cardboard square on top of the cup so that the water is completely covered. If the cardboard (laundry cardboard, for example) has a shiny side, put that side next to the water.

4. Place your fingers, palm of hand downward, firmly and flatly across the cardboard, holding the cardboard as much as possible against the rim of the cup.

5. Have a pan ready beneath in case the water spills. Holding the fingers in place firmly, turn the cup over.

6. Remove the hand that holds the cardboard, but do not change the hold on the cup with the other hand.

7. The air should hold the cardboard in place for a short while.

8. Replace the fingers on the cardboard and set the cup upright on the table top as at the start.

Remove the cardboard. Show the class that water is still in the cup (if it is).

Ask such questions as:

1. When a cup full of water is tipped, what happens to the water? (The water runs out.)

2. In this experiment, what did the cardboard do? (Held the water in the cup.)

3. Was the air pressing down on the cardboard square when it was first put on top of the cup of water? (Yes.)

4. If the cardboard measures 2 inches on both sides, what is its area? (Two inches long and two inches wide (Area = l x w); 2 inches x 2 inches = 4 square inches.)

5. If the air pushes (exerts pressure) of about 15 lb on each square inch, with how much force does the air push on the upper side of the cardboard? (4 square inches x 15 lb per square inch = 60 lb.)

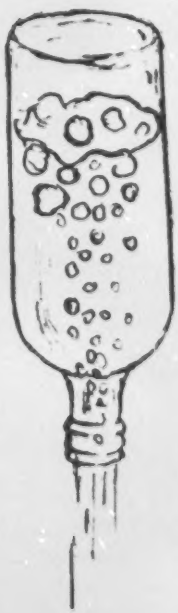
6. What is the air pressure on the cardboard? (15 lb per square inch.)

7. Does the air still push on the cardboard when the cup is inverted? (Yes.)

8. What pushes down on the cardboard? (The water in the cup and the air outside the rim of the paper cup where the corners of the cardboard square extend beyond the rim of the cup.)

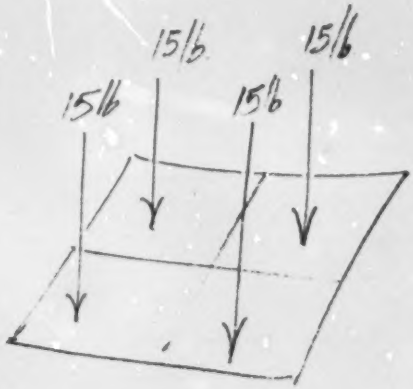
9. Is the downward push of the water greater than upward push of the air on the other side of the cardboard? (No. The upward push of the air is greater.)

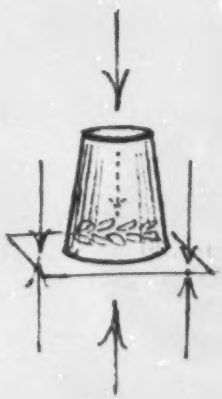
10. How about the air that pushes on the bottom of the inverted cup? Does that play a part in this experiment? (No. The bottom of the cup prevents this.)



11. A supplementary experiment is easily performed. Take a bottle with a very small neck, such as a soda bottle, fill it with water. While holding the bottle over a pan or the sink, invert it. Fill and invert it several times. Ask class what they saw. (Bubbles of air rise through the water. They saw the water surrounding the air bubbles.)

The air, however, cannot be seen any more than can the air in the room. We infer that the bubbles are bubbles of air. What caused the gurgling effect? (Water poured out and air bubbled in.)





EXPERIMENT NO. 3A

Repeat this experiment to find out about the push of the air on the bottom of the inverted cup.

This time make a pinhole in the bottom of the cup. Put a bit of tape that seals tightly over the hole and leave a tab by which the tape can be pulled off quickly. Turn ½-inch of the tape back onto itself to make the tab.

Repeat Experiment No. 3, steps **1** through **6.**

Hold the cup steadily as before (and over a dish), and pull the tab on the tape enough to expose the pinhole.

What happens? (The water and cardboard will fall.)

Questions

a. When the pinhole is opened, what pushes on the upper side of the cardboard? (Air and water.)

b. What pushes on the under side of the cardboard? (Air only.)

c. Which push is larger? (Air and water.)

d. Will the water remain in the cup when it is turned over onto the card if the experiment is repeated but this time the cup is filled only partially with water and the pinhole is closed? (Have the class predict and then try it. Ask questions similar to those of a, b, and c.)

16

EXPERIMENT NO. 4

Hot and Cold Air

Pupil Experiment
and
Teacher Demonstration

Purpose: To show that compressed air changes in temperature when it goes through a small opening into a place of lower pressure.

Materials Needed: Rubber balloon.

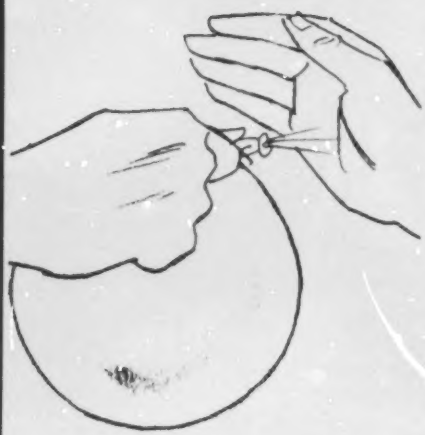
What to Do:

1. Have student breathe through his opened mouth while he holds one hand in front of his mouth. Waft the exhaled air over the hand. Note its temperature. Does it feel warm, cold, or the same temperature as the surrounding air? (Warm, probably.)

2. Now the students are asked to puff out their cheeks as if they were the walls of a balloon, and then blow their breath out a small hole formed by their lips. Does the air feel warmer, cooler, or at room temperature? (Cooler, probably.)

Note that when air goes from a place of higher pressure to a place of lower pressure, the temperature tends to become lower.

3. Check this observation by first drawing air into the slightly open mouth slowly, and then by drawing air rapidly into the mouth through a small hole in the lips. Does the air that enters the mouth through the small opening feel warmer, cooler, or the same temperature? (Cooler, probably.)



4. Maybe the temperature of the human body had an effect on the air. Let's check to see whether or not your mouth had anything to do with the temperature. The teacher now fills a balloon with air and the experiment is repeated using the air in the balloon. The opening of the balloon is now reduced by pinching the tube. The pressure or the air within the balloon is increased by squeezing the walls of the balloon together. A pupil holds his hand in the stream of air that escapes from the "mouth" of the balloon.

The air rushing out the small hole goes from a region of high pressure to the outside air which is at a pressure lower than that within the balloon. The pupil will probably report that the escaping air feels cooler.

5. Again, the balloon is inflated; the student reporter's hand is in place. The balloon's opening is left as wide as possible while the balloon collapses. What is the effect this time? (Perhaps a little cool.)

What have you observed?

1. When air goes from a place of higher to a place of lower pressure, it becomes cooler.

2. When air goes from one place to another without much difference in pressure, a very small temperature change may be noticed.

EXPERIMENT NO. 5

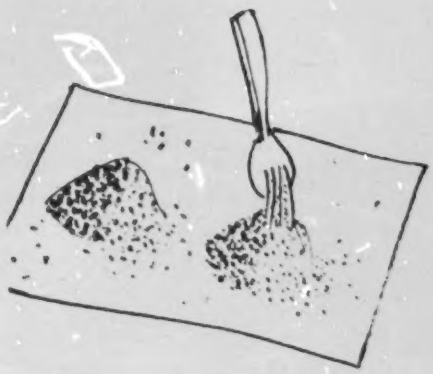
Making a Mixture of Solids

Teacher Demonstration

Air is composed of several gases mixed together. The two principal gases in air are oxygen and nitrogen, with carbon dioxide and a few other gases completing the mixture. An average composition of air by volume is nitrogen 78%, oxygen 21%, argon 0.93%, carbon dioxide 0.03%, other gases 0.04%. The make-up or composition of air varies slightly from place to place. That is, air near a city where much fuel is burned often contains slightly more carbon dioxide than does country air. Let's demonstrate what a mixture is by using two solids that we can see. There are mixtures of solids, liquids, and gases, but a mixture made of things we can see will most easily demonstrate what a mixture is and how mixtures made from the same things can differ.

Purpose: To make a mixture of solids and show how the composition (make-up) of the mixture can be changed.

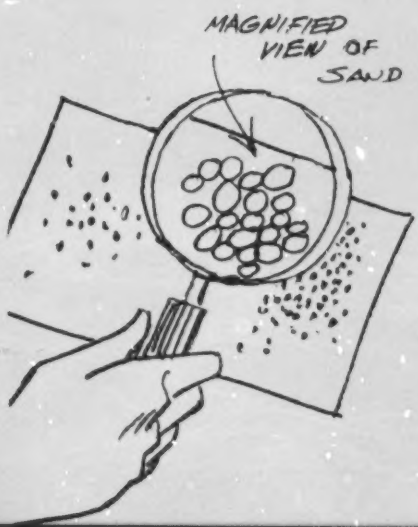
Materials Needed: Two teaspoons (plastic). Common salt. Sand (children's playbox sand or road sand). Sheet of paper. Magnifying glass (reading glass).



What to Do:

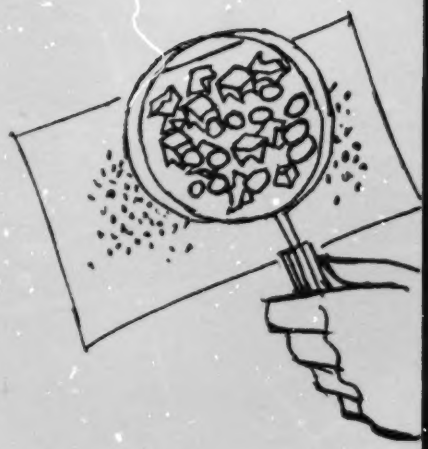
1. Place 2 teaspoonsful of salt on one-half of a piece of paper. Spread it out and look at it through the magnifying glass. What does the salt look like?

The salt appears to be tiny cubes or fragments of cubes, whitish in color. Make a sketch of them on the board.



2. Place 2 teaspoonsful of sand on the other half of the paper. Spread it out and look at it through the magnifying glass. What does the sand look like?

The sand appears as irregular particles, some rounded, some sharp edged, and sometimes of several different colors. Make a sketch on the blackboard of the magnified sand. Label both sketches.



3. Stir the salt and sand together. Do this by lifting the edges of the paper toward the center. Then stir with the handle of a spoon. Stir for a minute or two until the mixture you have made appears quite alike in all its parts. Look at the mixture through a magnifying glass. Is it still salt and sand, or is it something new? If you can still see cubic crystals of salt and grains of sand, it is a mixture. Show parts in the mixture by an enlarged sketch on the chalkboard or by projecting a thin layer of it by using the overhead projector.

4. Divide the mixture roughly in half, making two piles on the sheet of paper. Add a teaspoonful of salt to one of the piles. Stir this extra salt into the pile. If the sand is brown, then the pile to which the salt was added now appears lighter in color than the other pile. The make-up of the mixture has been changed.

How? (By adding more salt.)
How much? (See part 5.)

5. For those who wish approximate measure and wish to introduce the idea of ratio:

Start: 2 tsp salt + 2 tsp sand.
Parts: Salt to sand = 1 unit of salt to an equal unit of sand or 1 to 1
Result: 4 tsp mixture of salt and sand
Divide the mixture into two approximately equal parts.
Each pile now contains: 1 tsp salt and 1 tsp sand

Add 1 tsp salt: 2 tsp salt and 1 tsp sand

Parts when changed: Salt to sand = 2 to 1

What have you observed?

1. A mixture is made of parts.

2. The different parts in a mixture of solids can sometimes be seen.

3. The make-up of some mixtures of solids can be changed.

EXPERIMENT NO. 6

Making a Mixture of Liquids

Teacher Demonstration

A mixture of liquids is more like a mixture of gases than is a mixture of solids. It is helpful, therefore, to make a mixture of liquids.

Not all liquids mix well with each other. Oil floats on water but mixes into the water very slightly. For this experiment, select liquids that mix readily with each other.

Materials Needed: Water. White vinegar. Instead of white vinegar, isopropyl alcohol can be used. Other choices are glycerin, other alcohols, molasses, ammonia water. The last two contain much water already. Three empty jars (such as baby-food jars) or test tubes. Two teaspoons.

What to Do:

1. Measure two teaspoonsful of water and put them into a clear jar.

2. Measure two teaspoonsful of white vinegar into the same jar. Stir the mixture with the spoon.

3. The proportions are 2 tsp water to 2 tsp white vinegar or 1 part water to an equal part white vinegar or 1 to 1.

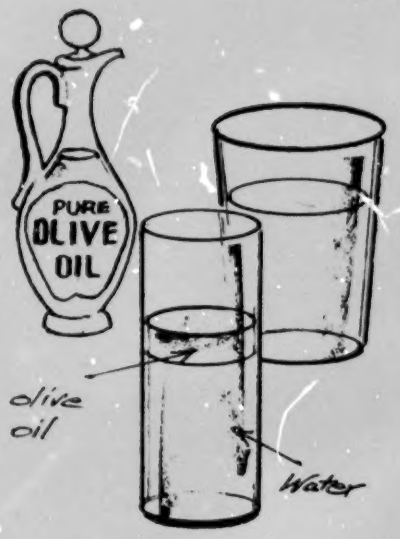
4. Change the composition of the mixture by adding two more teaspoonsful of water. Stir the mixture.

5. The proportions now are 4 tsp water to 2 tsp white vinegar or 2 parts water to 1 part white vinegar.

6. Ask the class what to do to make the mixture become three parts water to one part white vinegar. (Add two more tsp of water.) The first student who has the correct answer is asked to add the water and to make the mixture.

Questions

a. Can any two liquids be used in this experiment? (No. Oil and water do not mix well. Add a few drops of any cooking oil to water and show that complete mixing is not reached. Layers form.)



b. If 4 tsp water and 2 tsp white vinegar make a 2 to 1 mixture of water to white vinegar, what other numbers of teaspoonsful could be used? (6 to 3, 8 to 4, 10 to 5, etc.)

c. Is the mixture of water and white vinegar by volume or by weight? (By volume.) Equal parts (volume) of water and white vinegar do not weigh the same.

What have you observed?

1. Both solids and liquids can be parts of mixtures.

2. Some mixtures look very much like the individual materials from which they are made.

3. The makeup of some mixtures can be changed easily.

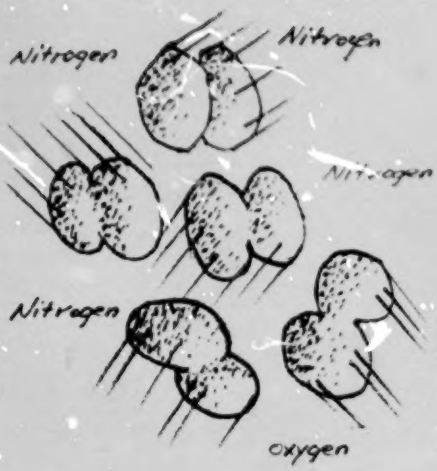
4. The makeup of some mixtures of solids and the makeup of some mixtures of liquids can be changed.

Gases can also be made into mixtures in a similar manner. And in a similar manner, the makeup of a mixture of gases can be changed. In fact, the makeup of air, a mixture of gases, changes within your lungs from the time you inhale it to the time you exhale it.

Note 1. In the case of gases, the mixture does not need to be stirred. Mixtures of gases stir themselves if they stand.

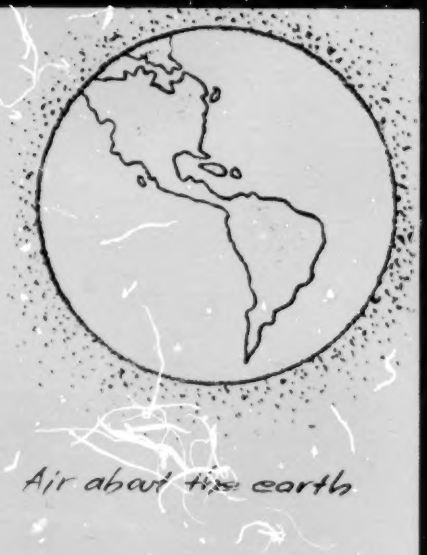
Grade level will determine the use made of Note 2.

Note 2. These statements do not hold in case a **chemical change** takes place between the parts of a mixture—whether solids, liquids, or gases. After a chemical change, a new substance, one not there before the change, is present. Sometimes more than one new substance is formed in a chemical change.



AIR IS A MIXTURE

The mixture called air is made up of gases. Air contains two principal gases, oxygen and nitrogen. These are both invisible gases so you cannot see them either separately or together, even with the help of a powerful magnifying glass. Air is made up approximately of four parts of nitrogen to one part of oxygen. These two gases are mixed up much better than the stirred-up pile of salt and sand. It extends upward about two hundred miles above the earth's surface.



EXPERIMENT NO. 7

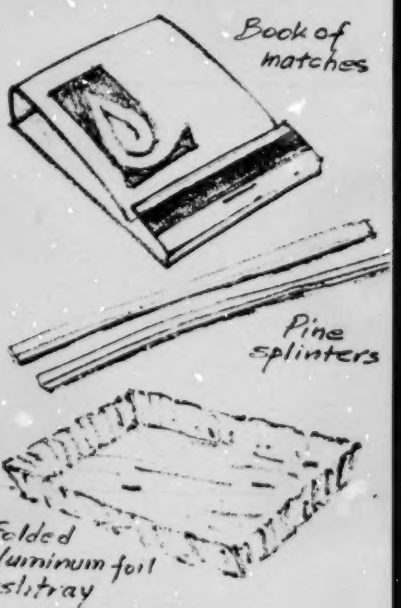
Burning in Air

Teacher Demonstration

It is difficult to show that air is a mixture. Experiments can show that part of the mixture of gases called air is connected with burning, something the students can see.

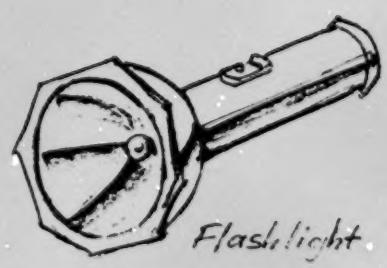
Purpose: To show that ordinary burning can go on in air.

Materials Needed: Matches. Splinters of pine wood. Candle in candle holder (candlestick). Empty food jar about three inches tall. Ash tray. Flashlight (not always needed). Forceps or tweezers.



What to Do:

Strike a match. Hold it horizontally by the end of the match stick. Watch it burn. Blow out the match and place the partly burned end in the ash tray.

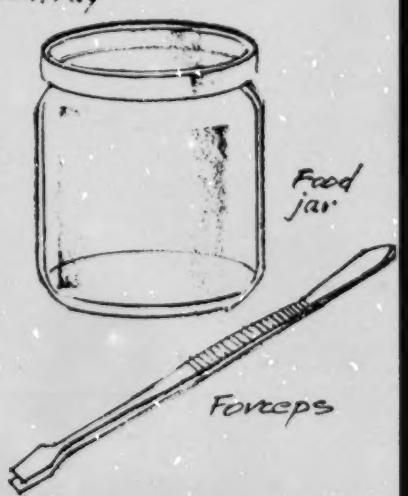


Questions

a. Did the match stick burn with a flame or with a glow? (Flame.)

b. Where was the flame in relation to the stick? (Near it and mostly above it.)

c. When the match was burning, what happened to the stick near the flame? (It got hot.)

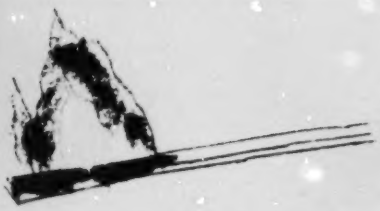


d. What does heating the stick cause? (It causes gas to escape from the stick, either wood or paper, and then burn.) What is the cause of the flame? (Burning gas driven out of the heated match stick.)

e. Is the air burning or is the match stick burning? (Stick.) (The gas driven off by the warm match stick combines with one of the gases (oxygen) in the mixture of gases called air.)

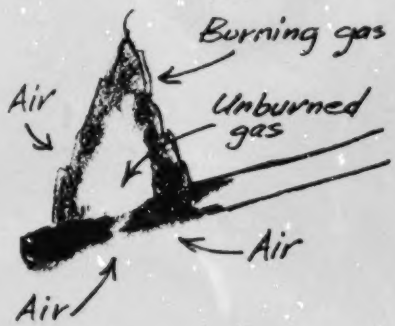
What to Do:

Light the candle. Use the candle flame to set a wooden splint afire. Hold this splint horizontally as before; allow it to burn almost completely, and then place it in the ash tray. After the class has seen this happen, burn another splint, but ask questions.



Questions

a. What made the splint start to burn? (It became hot.)



b. Does the splint burn with a flame? (Yes.)

c. What causes the flame? (The gases, driven out of the wood by heating, burned.)

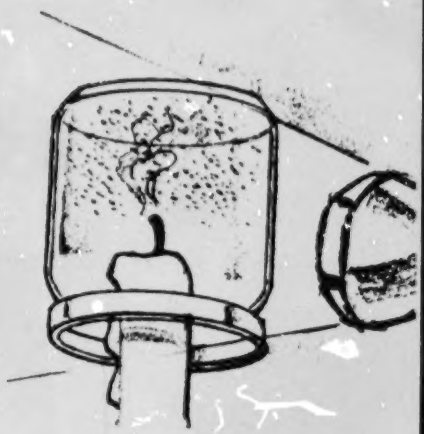
d. Does the blackened end of the splinter burn with a glow (spark)? (Yes.)

e. Burning with a glow takes place when a solid burns. After all the gases are driven out of the wood, a black solid is left. This black solid burns with a glow and is used for outdoor cooking. What is it called? (Charcoal.)

f. Does all of the stick burn? (No. Some wisps of gray ash are usually seen.)

What to Do:

Light the candle. Invert the empty food jar and hold it over the flame so that the flame is in the center of the jar. Continue to hold it in this position for a minute or two. The flame may go out. If the flame hits the wall of the jar, black soot (unburned carbon) may be deposited. In the upper part of the inverted

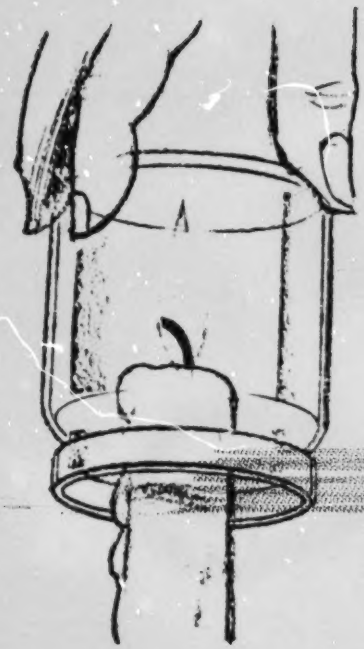


jar, observe a clouding caused by condensed moisture (water vapor changed to liquid water). A beam of light from a flashlight may help show the clouding to the class. Compare the lower with the upper part of the jar in the light beam.

Discussion

Why does the flame dim or go out? (The candle flame went out because it used up a part of the air that is needed for burning.) What caused the moisture to form on the jar? (The moisture that formed as droplets on the upper, inner part of the jar was caused by burning. The oxygen of the air combines with the gases from the candle wax which is the fuel and forms steam (water vapor) as one product. The water vapor became droplets of liquid water when it cooled against the glass.)

What gas or gases were left in the jar? (Gases, in addition to water vapor were also left in the jar. These gases are nitrogen, the unused, inactive part of the air; carbon dioxide (a product of burning); some unused oxygen; and a little argon. All are colorless and invisible. To the eye, the mixture appears the same as air, but it does not have enough oxygen in it to let burning go on in it. Try it. Put a burning candle into the same inverted jar.)



What to Do:

Light the candle. While the candle is burning, place the wick within the ends of a pair of forceps. Press the jaws of the forceps strongly together. The candle burns less brightly and may go out completely.

What made the candle go out? (The fuel was shut off. Both air (oxygen) and fuel are needed for burning.)

What have you observed?

In order for burning to take place there must be:

1. a supply of fuel

2. a supply of a gas (oxygen); this is part of the mixture of gases called air

3. a relatively high temperature to start the fuel burning

The candle flame went out or was lowered when the forceps pressed firmly against the wick. (Fuel supply reduced or cut off). The candle flame went out after burning under an inverted jar. (Air (oxygen) supply not enough.)

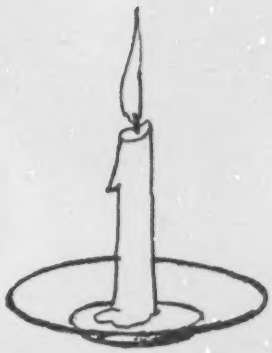
EXPERIMENT NO. 8

Candle Wax Vaporizes
Before It Burns

Teacher Demonstration

Purpose: To show that candle wax vaporizes or changes to a gas before it burns.

Materials Needed: Candle in candlestick. Matches.



What to Do:

1. Light the Candle. Light a match and have it ready to use after explaining what is to be done.

2. Blow out the candle with a sharp puff of your breath.

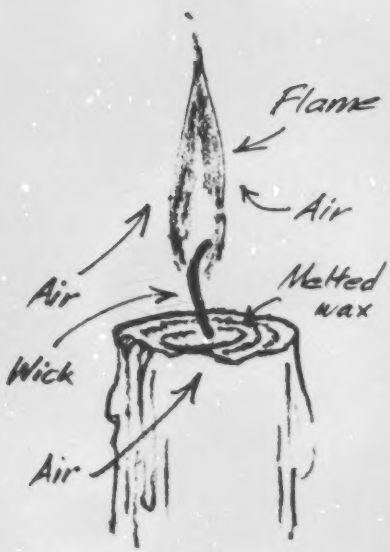
3. Immediately light the "smoke" or vapor from the wick about one-half inch from the end of the wick.

4. If not successful, repeat steps 1, 2, and 3.

What have you observed?

The lighted match was not placed at the wick, but in the hot vapors coming from the wick. These hot vapors are coming all the while a candle is burning. The vapors from hot candle wax are burning as a gas.

We can see the candle in its solid form. When it changes to a gas, the gas is invisible. When the candle vapor and the air (oxygen) are mixed and ignited, the mixture of gases burns with a flame. We conclude that it is the candle wax vapor and the oxygen from the air (both invisible) that produce the flame (visible).

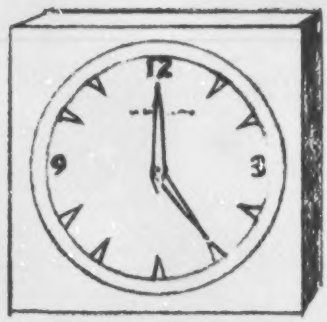


EXPERIMENT NO. 9

How Fast Does A Candle Burn?

Student Experiment

Purpose: To show that a burning candle uses fuel and to measure the rate of use. To develop the concept of measurement of rate of use, using quantity and time.



Materials Needed: Candle (cylindrical, straight sides). Matches. Ruler (metric or English). Timer (classroom clock may be used).

What to Do:

1. Select a candle used for decorating a dining table, not the kind that drips extra wax along the side when it burns. Try this out before the experiment is used with a class.

2. Set the candle in a candlestick or on any object that holds it rigid.

3. Measure the height from the top of the candle (at base of wick) to the table top.

4. Light the candle and make record of the time at which the candle is lighted.

5. Allow the candle to burn for several hours if possible. A measurement can also be made if the candle is started at the beginning of a class period and put out near the end of the period.

6. Record the time when the candle is put out and measure the height of the candle then.

Record	Measured	Calculated
(a) Time of start	_____	
(b) Time of end	_____	
Time used		_____

(c) Height at start _____

(d) Height at end _____

Height of candle burned _____

Conclusion: Find the height of candle burned per hour.

Sample Calculation

(a) Start 9:30

(b) End 1:10 (use 13:10)

In subtracting minutes "borrow" one hour, 60 min.

12 hr. 70 min - 9 hr 30 min = 3 hr 40 min

(c) Height, start 14¼ in.

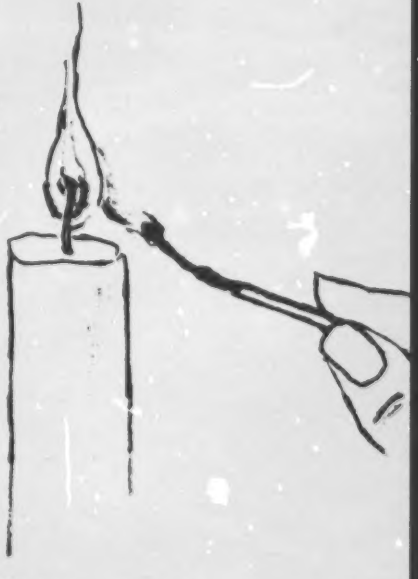
(d) Height, end 11-5/8 in.

Either 14.25 in. - 11.63 in. = 2.62 in.

or 13 10/8 - 11 5/8 = 2 5/8 in.

2 5/8 in. in 3 hr. 40 min. = 2.62 in. burned in 3.67 hr.

By division: 2.62 in. ÷ 3.67 hr. = 0.72 in. in one hr.



What have you observed?

1. Air (oxygen) is continuously supplied to support burning. (Where does it come from? Why isn't it used up as in Demonstration #7 when the candle flame is covered?)

Light a match. Blow it out and while it is still smoking put it alongside the candle near the flame of the candle. Which way does

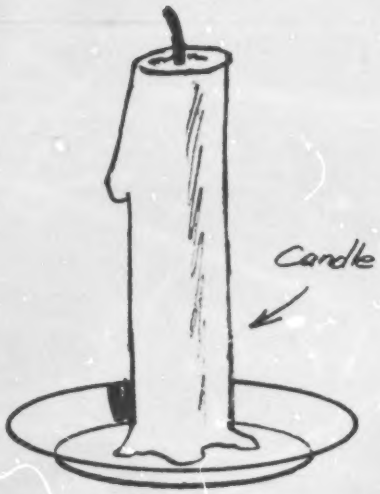
the smoke move? What does this show about the way the air is moving toward the flame?

2. The rate at which a fuel (candle) burns can be determined. What further deductions can we make? (If we know how long we need a candle flame, we can determine how many candles are needed.)

EXPERIMENT NO. 10

Incomplete Burning

Teacher Demonstration



When solid or liquid fuels burn, they sometimes burn incompletely. It is well known that gases from the tail pipe of a car contain poisonous carbon monoxide. This poisonous gas is caused by incomplete burning of gasoline. Carbon monoxide, however, can itself burn and form carbon dioxide. While incomplete burning of gases is also easily done, the results of incomplete burning of fuel oil are very commonly seen, as in the smoke of a chimney or smoke from an exhaust pipe of a truck, car or airplane.

We shall cause incomplete burning by cooling a flame. Incomplete burning can also be caused by a low supply of air (or of oxygen).

Purpose: To explore a candle flame and to illustrate that a cooled flame can cause incomplete burning and make soot.

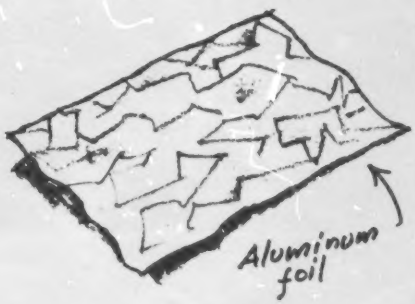
Materials Needed: Candle in holder. Strip of aluminum foil or cardboard. Sheet of white paper. Matches.

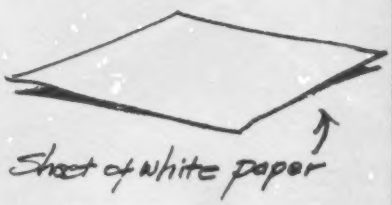
What to Do:

1. Light the candle and place it where it can be seen easily from all parts of the room.

2. When the candle is burning brightly, hold a piece of aluminum foil or a small piece of cardboard briefly in the flame above the wick and in the lighted part of the flame. Keep the foil moving while it is in the flame. Remove it.

3. After the aluminum or cardboard has cooled, rub it gently against a sheet of white paper. The paper should show a dark, sooty streak. The transfer from the probing material to the sheet of paper shows that the probe has not become scorched. A black material (soot) was formed.

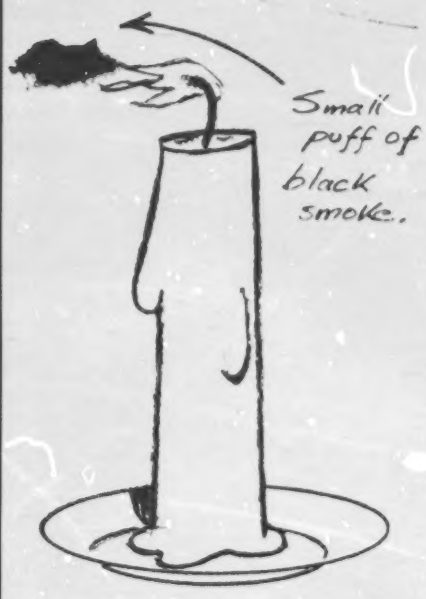




4. Sometimes the flame can be cooled by waving one's hand near the flame. (Try it.) A small puff of black smoke can be seen. The smoke becomes more easily seen if a piece of white paper is used as a background.

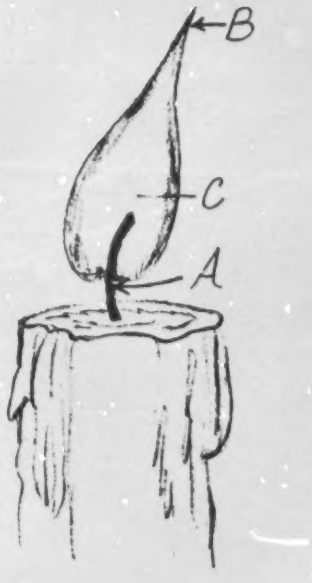
Questions

a. Does the foil make the temperature of the flame higher, lower, or produce no effect? (Lower, cooler.)



b. What is the effect of putting the foil or cardboard into the flame? (Soot formed on the foil or cardboard.)

c. From what part of the flame is the soot formed most readily? (Explore and find out. Use a small piece of foil. Try above at top (B), near and below the wick (A), and in the light-giving part of the flame (C). C is expected to give the most soot.)



d. How is the soot on the foil different from the soot in the flame? (Soot is cool on the foil. Warm, even hot soot is in the flame. In fact, the soot in the flame is so hot that it glows. This glowing soot makes the candle flame a source of light.)

Discussion

Fires that burn incompletely and produce soot put soot particles into the air. These fires cause air pollution. Smoke can be seen coming from chimneys. Smoke can also be seen coming from diesel engines, especially from diesel engine trucks going uphill. Airplane engines (jet) at take-off may cause and scatter as much as 80 pounds of soot. In each case, incomplete burning takes place. Usually the flame is cooled by a metal, just as in this experiment.

To avoid such pollution, burn the soot. It is easy to suggest this simple way to get rid of this sort of pollution, but it is difficult to do it.

The air does have ways of purifying itself. Rain washes the larger solid dirt and soot out of the air. Raindrops form around tiny particles, so many of the particles that do not settle easily are brought to earth within raindrops.

What have you observed?

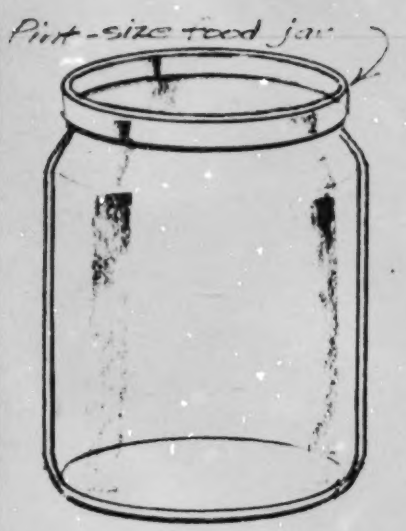
1. If the flame burns ordinarily, the soot is burned.

2. If the flame is cooled (perhaps by a piece of foil within the flame) soot is formed.

3. The hot soot within the flame sends out light from the candle flame. The hot soot burns completely at the edges of the flame where it meets oxygen from the air.

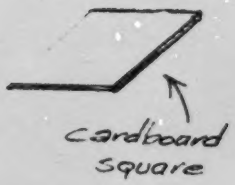
EXPERIMENT NO. 11

Making Carbon Dioxide Gas



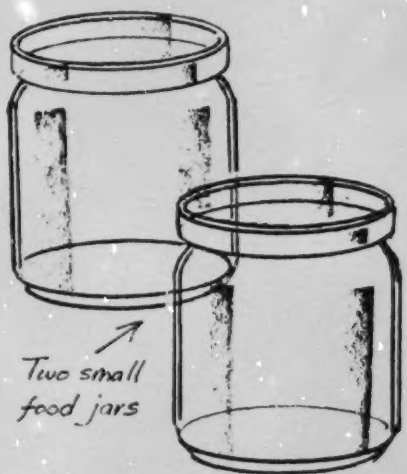
Teacher Demonstration

When carbon or carbon-containing materials burn completely in air, carbon dioxide is formed. This method of making carbon dioxide isn't useful as a schoolroom method because the carbon dioxide gas is hot when it is formed by burning. If the carbon dioxide gas is at room temperature, it is easier to handle.

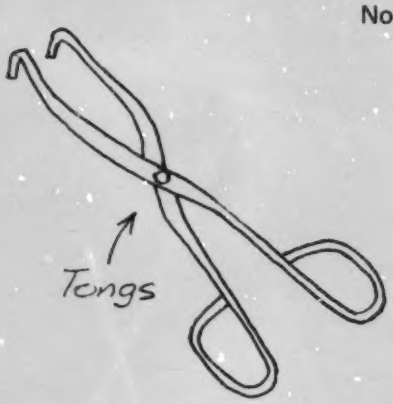


Purpose: To make carbon dioxide and to find its relationship to burning.

Materials Needed: A. Food jar (about pint size). Two smaller glass jars. A cardboard square to cover the mouth of the smaller jar. Small candle in a stand. Matches. Ash tray. Clear limewater solution. (If the liquid isn't clear, let the sediment settle and carefully pour off the clear liquid above.) Dry Ice. Tongs or cloth to handle Dry Ice.



B. If Dry Ice isn't available: Use the same materials as above and also these: Baking soda (bicarbonate of soda). Vinegar (or any other acid). Paper towels. Old newspaper to cover working surface.



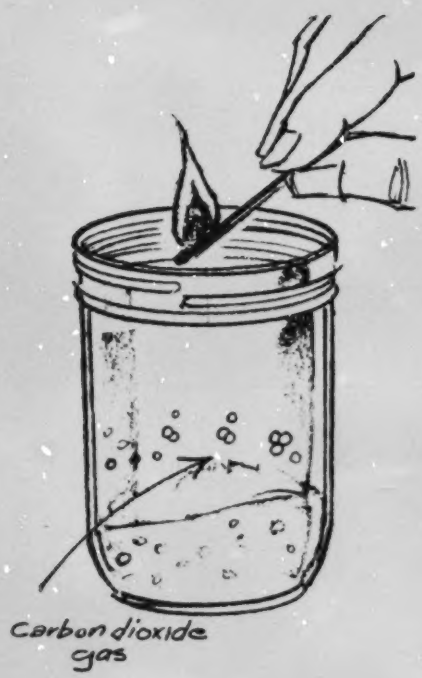
Note: If any limewater or acid gets on your hands, simply wash it off with soap and water. If any by chance spatters into your eye, flush with water copiously. Wearing protective glasses is advised.

What to Do: A or B

A.1. Place a chunk of Dry Ice about the size of a golf ball in the bottom of the largest food jar. Handle the Dry Ice with protective layers of cloth or paper towels or with tongs. Do not touch it with unprotected fingers.

CAUTION: Never put Dry Ice into a screw-cap jar. It may cause an explosion if it is confined.

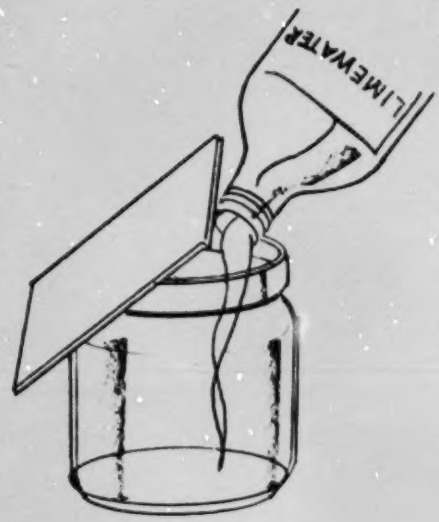
B.1. Put a layer of sodium bicarbonate about one-quarter inch deep in the bottom of the largest jar. Pour the acid solution onto this white powder. Add enough to get a very generous supply of bubbles, enough to fill the entire jar with gas and have some overflow.



2. Is the gas colored? (No.) Some dust of sodium bicarbonate powder may appear to give the gas a color. Does it have a noticeable odor? (No.)

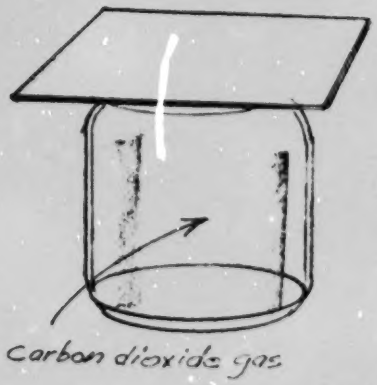
3. Bring a lighted match over the mouth of the jar in which the carbon dioxide gas was made. Does the gas burn? (No.)

4. Place a lighted match into the carbon dioxide gas. What happens to the burning match? (Match flame goes out.)



5. Pour a little limewater solution into one of the smallest jars. Use the other jar and bail some gas out of the larger jar into the jar that holds the limewater solution. Place a small cover of cardboard over the jar containing the gas and the liquid and swirl the two together. (Limewater becomes cloudy.)

6. Set up the following experiment in advance, and practice it. Light the small candle. Pour the gas only from the larger jar into the small jar. Cover the smaller jar. Move the mouth of the smaller jar near to and above the small candle flame. Pour the gas quickly from the lower side of the smaller jar onto the flame. (Flame may go out if enough gas is poured.)



This series of actions (if successful) shows that the carbon dioxide gas can be poured almost as if it were water. Which is the heavier, air or carbon dioxide under the same conditions? (Carbon dioxide)

What have you observed?

1. Carbon dioxide is colorless.

2. Carbon dioxide is odorless.

3. Carbon dioxide does not burn.

4. Carbon dioxide causes burning to slow down; and if enough surrounds the burning object, the flame goes out.

5. Carbon dioxide causes limewater to become cloudy.

6. Carbon dioxide is heavier (denser) than an equal volume of air.

EXPERIMENT NO. 12

Carbon Dioxide in Exhaled Air

Demonstration by One or More Students

Some of the food we eat is changed to energy in the human body by using the oxygen in the air we inhale (breathe in). This process of liberating energy also forms water (as seen in another experiment) and carbon dioxide gas which we exhale (breathe out).

Purpose: To find carbon dioxide in exhaled air by using a procedure or process established by previous observations.

Materials Needed: Limewater solution. Glass food jar. Soda straws.

What to Do:

1. Pour about a one-fourth inch layer of limewater solution into the glass jar.

2. Exhale into the liquid by blowing through a straw into the clear liquid. What happens to the clear liquid?

3. Continue exhaling into the liquid. Use the air from the deeper recesses of the lungs which is rich in carbon dioxide. This experiment requires several minutes and may require several blowers. If the gas in exhaled breath changes clear limewater so that it contains a white cloudy material and then with much more gas (exhaled breath) changes back to a clear liquid, then it is indeed carbon dioxide gas, the only gas which does this.

The white cloudiness is caused by bits of a solid, marble-like or limestone-like substance forming in the solution. The effect of excess carbon dioxide gas is to dissolve the solid substance. This same process in nature has resulted in the formation of limestone caves.

What have you observed?

1. Something in exhaled breath caused limewater to turn milky. (From previous Demonstrations/Experiments, we might infer that exhaled breath contained carbon dioxide.)

2. Continued exhaling of breath into the milky limewater caused the limewater to clear (or partly clear).

CONCLUSION

One of the great debates in the early years of science was over the question, "Do things gain weight or lose weight when they burn?"

Those who reasoned from incomplete evidence said, "Certainly the ashes that are left after burning weigh less than the wood that was burned. It is clear that everything loses weight when it burns. What is left when a candle burns? Nothing! There can be no doubt about it."

Other people, convinced that such evidence was not enough, burned a weighed candle and caught the substance formed by burning. To their amazement, they found that wood, coal, candles, and other fuels all gained weight when they burned.*

Today we have a simple explanation for the reason that weight is gained when fuels burn. When fuels burn, they combine with oxygen. The action of adding oxygen increases the weight. In addition to heat, the major products of burning are gases—usually water vapor and carbon dioxide. They cannot be seen when they leave the flame of a candle. When people began to understand that invisible gases are real substances, they began to understand nature better.

This understanding about gases came to mankind slowly. At the time of the American Revolution (about 1774), not one soldier who warmed himself at a campfire knew what was happening when wood burned.

It isn't a simple matter to understand about gases which are invisible. We must infer or deduce something about colorless gases from the way they behave. Some invisible, colorless gases (such as methane, hydrogen, or carbon monoxide) burn. Other invisible gases (such as nitrogen, carbon dioxide, or argon) put out ordinary fires. Some invisible, colorless gases are denser than air (1.29 grams per liter at standard conditions); others less dense. See **Facts about Gases**, p. 42. One common gas (oxygen) is needed for burning.

We can distinguish between these colorless invisible gases by the way they act. At the beginning, however, new learners need to infer that this "nothing" that they cannot see in an apparently empty bottle is a gas. If the "nothing" makes limewater become cloudy, they are told that the gas is called carbon dioxide and that carbon dioxide is the only gas that makes such a change.

We ask our pupils to accept the names of the gases and to associate them with certain actions as an act of faith. How much more that faith is reinforced if the actions can be shown clearly by a demonstration or an experiment.

* An experiment of this sort can be duplicated with a large two-pan balance. On one pan is a short candle and over it is a chimney suspended from the same place that the pan is suspended. The chimney contains some glass wool which serves as a porous pad at the bottom, and the chimney is packed loosely with sticks of lye (sodium hydroxide). Sodium hydroxide absorbs both moisture and carbon dioxide which are the products from a burning candle. Handle sodium hydroxide with forceps. Do not touch it.

Before lighting the candle, weights are placed on the other pan of the balance until the two pans are balanced and at rest in equilibrium.

The candle is then lighted. The pan that holds the candle and chimney gradually lowers, showing that it becomes heavier. We know now by this sort of an experiment and many others much more refined and precise that all fuels gain weight when they burn.

In this booklet we have developed a concept about gases in general, reinforcing faith by interest and building on that interest by showing certain general characteristics of gases and how one gas differs from another.

In the course of these experiments we have developed several concepts. Among them are:

1. The air that is about us is one example of a mixture of gases.
2. Colorless, odorless gases may appear to be ordinary air. Until certain tests are made, it won't be known whether or not the gas is ordinary air.*
3. By making tests, we can obtain evidence to help us decide what a gas may be.
4. We use the results of tests to decide whether or not two colorless gases are the same.
5. The principle of using the results of tests to infer or decide what a gas may be implies that each different substance has a set of properties or characteristics that are unique, or unlike the set of properties of another substance.
6. Care must be taken to avoid mistakes. Usually more and more evidence is needed before facts tentatively established by inference are generally accepted. Are we sure, then, that a gas which turns limewater milky can be identified as carbon dioxide? Many other gases have been tested and none of them turned limewater milky. Here we used the results of the experiments of many other people. It is necessary, therefore, that experimenters in science make a record of their work, and that other scientists read and understand what has gone on earlier. For example, penicillin which is so widely used today, is described in the writings of Sir Alexander Fleming who first isolated and identified **Penicillium notatum** in 1928. John Tyndall, about 50 years previously, had observed the effect that Fleming examined. Later during World War II, penicillin was grown, isolated by Sir Howard Florey, and used successfully to heal wounded soldiers in 1943. Each scientist built on the work of others.
7. The important attitude of asking questions and searching for answers is developed.
8. We have touched on the idea that things, facts, and answers, should not be taken for granted. They are all subject to continual rechecking.
9. These experiments also emphasize step-by-step thinking. We may wish to determine if carbon dioxide is heavier than air. One sample of the invisible gas is left uncovered in an upright bottle. Another sample is left uncovered in an inverted bottle. After a few minutes, both bottles still contain colorless invisible gases and the direct evidence obtained by looking at the two bottles shows no change. The contents of each bottle are tested with limewater. Carbon dioxide which turns limewater milky is no longer in the inverted bottle, but it remains in the upright bottle. This behavior is that of a gas denser than air. We may then infer that carbon dioxide is denser than air. Here indeed we infer from evidence other than that obtained by looking at gases which change unseen even while we watch.

* Natural gas (mainly methane) is colorless and odorless. A distinctive odor is added to natural fuel gas in order that leaks may be discovered and corrected. For a sample of the odor, scratch the "sniffer" patch on the folders supplied.

10. One other concept has been suggested. This may be called the "spirit of inquiry" or finding out additional information by asking disciplined questions. Try variations of these experiments. If a student asks a question, can his question be answered by his own reasoning from an experiment? Try it.

We hope that both you and your pupils thoroughly enjoyed learning and exploring with WHAT IS A GAS?

SUMMARY

The three states (phases) of matter have been explored. Solids and liquids are already familiar. Gases are less familiar because many of them are invisible.

Water is well known as

solid - ice
liquid - water
gas - water vapor (steam)

We cannot see water vapor. If water vapor changes to a liquid, then we may see it. It may be seen as a cloud or a fog, made up of small drops of liquid water.

We have also explored mixtures. Sand mixes with salt, forming a mixture. Sand does not combine chemically with salt. The term "combine" is kept for chemical actions. Vinegar combines chemically with baking soda. Fuel combines chemically with oxygen from the air when burning takes place. The products of burning are usually steam and carbon dioxide. The steam and carbon dioxide, if allowed to escape, may mix (not combine) with the air.

For those who like adventuring mathematically, we have shown how the composition of a mixture may be changed. This change was brought about between solids as well as liquids.

This mixing suggests a project. Make mixtures of several sorts of materials, two at a time. Such materials could be white sand, brown sand, garnet sand, black sand, brick dust, cement, earth, sugar, or any other readily available solid. Have ten numbered identical containers. No. 1: contains, for example, all cement; No. 2: 9 parts (teaspoonsful) cement, one part white sand; No. 3: 8 parts cement, 2 parts sand; No. 4 . . . . . ; No. 9: 1 part cement, 9 parts sand; No. 10: all white sand. Have the students fill in the missing mixtures, which should show a gradual change of color.

The relationship of air to burning was explored. A part of air, oxygen, aids burning. The product of burning carbon is carbon dioxide, and this gas was investigated.

The handiest source of carbon dioxide is our exhaled breath. The carbon dioxide in exhaled breath is only one part of a mixture of gases.

These experiments are by no means "cut and dried." They are dynamic. You should be on the watch for better ways of doing these experiments each time they are performed. Give some thought to visibility. Be sure that the youngster who has sat in the back seat all during his school career sees as well as the youngster who sits in the front seat. Sometimes a screen of some kind behind the experiment improves its visibility. A 150-watt spotlight can be installed so that it lights up the experiment but does not bother the experimenter.

An important part of a demonstration/experiment is class participation. If a lot of simple questions are asked, the students can answer simply and quickly, and possibly with enthusiasm. (A few samples of possible questions and responses are given with some of the demonstrations.)

Many other simple experiments are possible. For example, carbon dioxide can be made in other ways besides those shown.

1. Uncap a bottle of carbonated beverage. Hold fingers over mouth of bottle and shake the contents gently. Carbon dioxide collects under the finger.

2. Put an effervescent tablet into water. The gas released is carbon dioxide.

3. Add water to baking powder. The gas released is carbon dioxide. The gas makes bubbles which give fluffy texture to cakes.

4. Sour milk and baking soda, cream of tartar and baking soda and water, and vinegar and baking soda all release carbon dioxide.

5. Dry Ice is solid carbon dioxide. Put a chunk of it into water and you'll see carbon dioxide gas bubbles. Don't handle Dry Ice with your bare fingers!

OTHER RESOURCES

Your local gas company or the American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 22209 will be glad to supply extra copies of this booklet, one to a teacher.

Also Available

"Experiments with Gas." A book of 28 general science experiments for the classroom and for projects. Junior high-school level, No. N00080. One per teacher.

"History of Natural Gas." Comic book giving the story of the gas industry. No. N00430. Classroom quantities.

"The Story of Natural Gas Energy." A 48-page booklet on past, present, and future of natural gas. Fifth grade and up. No. N00480. One per teacher.

Facts About Gases

Name	Chemical Symbol or Formula	Density (grams per liter, standard conditions)	Color	Odor	Dissolves in Water
Argon (element)	Ar	1.78	None	None	Same as oxygen
Carbon Dioxide (compound)	CO_2	1.98	None	None	Well with pressure
Carbon Monoxide (compound)	CO	1.25	None	None	Slightly
Chlorine (element)	Cl_2	3.21	Green	Like bleach	Well
Methane (compound)	CH_4	0.72	None	None	Slightly
Nitrogen (element)	N_2	1.25	None	None	Slightly
Oxygen (element)	O_2	1.43	None	None	About 4/100

Supplies

S = for each student

T = for demonstration by teacher

Experiment Number		
1		S Strip of paper 1 in by 4 in S Pencil
2	T Toy Rubber balloon	
3	T Paper drinking cups	T Cardboard square to cover opening of cup
	T Aluminum pan	T Cellophane tape such as Scotch brand
4	T Toy rubber balloon	
5	T Plastic spoons	T Sheet of paper
	T Salt	
	T Sand	
	T Magnifier	
6	T White vinegar or other liquid such as rubbing alcohol that mixes well with water	T Three empty glass food jars (baby-food jars)
	T Plastic spoons	
7	T Book of matches	T Candlestick or other candle holder (mouth of a bottle)
	T Pine splinters	
	T Candle	T Clear glass food jar, about 3 inches high
	T Forceps	T Ash Tray for used matches
		T Flashlight (optional)

Experiment Number		
8	T Candle in holder	T Ruler or yardstick
		T Timer
	T Matches	
		T Ash Tray for used matches
9	T Candle in holder	T Ash Tray for used matches
	T Matches	
10	T Candle in holder	T Ash Tray for used matches
		T Sheet of white paper
	T Matches	
	T Strip of aluminum foil or cardboard	
11	T Candle in holder	T Food jar, pint size (mayonnaise jar)
	T Matches	T Cardboard squares to cover opening of jar
	T Solution of limewater	T Dry Ice (optional)
	T Baking soda	T Cloth or tongs if Dry Ice is used
		T Ash Tray for used matches
		T Smaller glass jars (baby-food jars)
	T Vinegar (white)	
		T Old newspaper beneath experiment
12	T Limewater solution	S Glass food jar (for one or two students)
		S Soda (or milk) straws